

JACKSON STATE FOREST  
CONTINUOUS FOREST  
INVENTORY (CFI)  
DATABASE  
1959-2005

GENERAL REFERENCE

April 2007 version

*CALIFORNIA DEPARTMENT OF  
FORESTRY AND FIRE  
PROTECTION*

# CONTENTS

CONTENTS .....	1
PURPOSE OF DATABASE .....	2
VERSION .....	2
INSTALLATION .....	2
CFI OVERVIEW .....	2
PLOT HISTORY .....	3
PLOT LAYOUT .....	3
1959 to 1984 .....	3
1989 to 2005 .....	4
TREE DATA .....	4
FORM NAVIGATION .....	5
DATABASE ORGANIZATION & USE .....	6
DATA ENTRY/EDIT .....	6
REPORTS .....	6
<i>Setup and Manage Units</i> .....	6
<i>Unit Summary Reports</i> .....	7
APPENDIX I. TREE NUMBERING AND PLOT RE-CONFIGURATION ISSUES .....	9
TREE NUMBERING INCONSISTENCIES .....	9
PLOT SIZE RECONFIGURATION .....	9
LIST OF COMMON CHANGES MADE TO CORRECT TREE TRACKING ISSUES .....	9
HISTORY OF TREE NUMBERS AS USED IN THE FIELD AND IN THE DATABASE .....	10
APPENDIX II. EQUATIONS FOR HEIGHT & VOLUME ESTIMATION .....	12
HEIGHT-DIAMETER EQUATIONS .....	12
1959 CFI .....	12
1964 through 1984 CFI: .....	12
1989 CFI and IFI: .....	13
2005 FRI: .....	13
VOLUME EQUATIONS .....	14
1959 Board Foot Volume .....	14
1989 Board Foot Volume .....	14
1984 Cubic Foot Volume .....	15
APPENDIX III. GROWTH ROUTINE ASSUMPTIONS .....	17
APPENDIX IV. EXPORT TO CRYPTOS .....	19
SITE INDEX USED FOR CRYPTOS EXPORT .....	19
APPENDIX V. GROWTH CALIBRATED BY GROWING SEASONS .....	20

# PURPOSE OF DATABASE

This database is designed to facilitate the management of the JDSF Continuous Forest Inventory (CFI). This database has the following objectives:

- 1) Capture the data in electronic form for ease of analysis by Forest staff and researchers.
- 2) Provide timely feedback to crews to improve data quality.
- 3) Allow the grouping of plots in any configuration for the purposes of reporting unit statistics such as trees-per-acre, basal area, volume, etc.
- 4) Allow the export of plots to CRYPTOS growth modeling program.

The purpose of this document is to provide a general introduction followed by documentation of the use of the database and the processing and associated assumptions that went into creating the database.

## VERSION

This version, 1.0, is the first delivered version of the database with this manual, delivered April, 2007. This version is written in MS Access 2000 and 2003 with a MS Access 2000 format.

## INSTALLATION

Create a subdirectory in a location of your choosing (preferably on a drive that is regularly backed up) called "CFI". Create a subdirectory under "CFI" called "Cryptos".

Install the database by copying the .mdb file to the "CFI" directory. Copy the contents of the Cryptos directory to the "CFI\Cryptos" subdirectory.

Double clicking on the .mdb file will launch the application.

## CFI OVERVIEW

The Continuous Forest Inventory plots were installed in 1959. Forest managers recognized the need for a "system of frequent repeated inventories designed to keep a current record of changing forest conditions ... to assure stability and continuity of management. [To achieve this] it is necessary to know the total merchantable volume of timber, its rate of growth, and the structure of the stand." 143 plots were installed on a systematic grid with an interval of sixty chains. This would result in an accuracy estimate for gross board foot volume of  $\pm 12\%$  with a 5% confidence interval.

Subsequent measurements were made in 1964, 1969, 1974, 1979, 1984, 1989, 1999, and 2005. Generally the plots are re-measured every five years. However, the 1994 measurement was missed, and 6 years elapsed between 1999 and 2005.

In 1989 the field procedure underwent major changes. Most significantly, the plot size changed from a ½ acre rectangular plot to a 1/5 acre circular plot. This presents significant challenges for the continuity of growth estimates from 1984 and previous to 1989 and later. Some of these challenges are addressed in Appendix I. Additionally, there were many minor changes in the types of attributes and their allowed values collected for each tree. These changes are described in table 1 below.

## **PLOT HISTORY**

Below is a table showing the number of potential plots for each year and the number of actual plots installed each year. The *missing plots* column names plots that should have been installed, but no plot sheet was found.

Table 1.

Cycle	# of possible plots	# of actual plots	Missing plots	Remarks
1959	144	144	-	
1964	144	143	03-06	
1969	144	144	-	
1974	142	142	-	16-08 & 17-07 were dropped when a parcel was given up by State due to Mendocino Headlands SP purchase
1979	141	141	-	07-09 dropped when parcel was transferred to Parks and Recreation
1984	141	141		
1989	141	139	02-06, 03-08	Plot size change from ½ acre to 1/5 acre
1999	141	141	-	11-03 not found. 11-03b installed
2005	141	141	-	11-03 again in place of 11-03

## **PLOT LAYOUT**

### **1959 to 1984**

The ½ acre main plot is used to record trees 11.0" diameter breast height (DBH) and greater. The 1/4 acre subplot was only used in 1959. Heights were measured for all conifer trees which were used to develop height-diameter relationships. The 1/25 acre subplot is used to record pole size trees from 3.0" DBH to 10.9" DBH. The 40 1-milacre (6.6 ft<sup>2</sup>) subplots are used to record presence of (stems are not counted) coniferous reproduction less than 3.0" DBH.

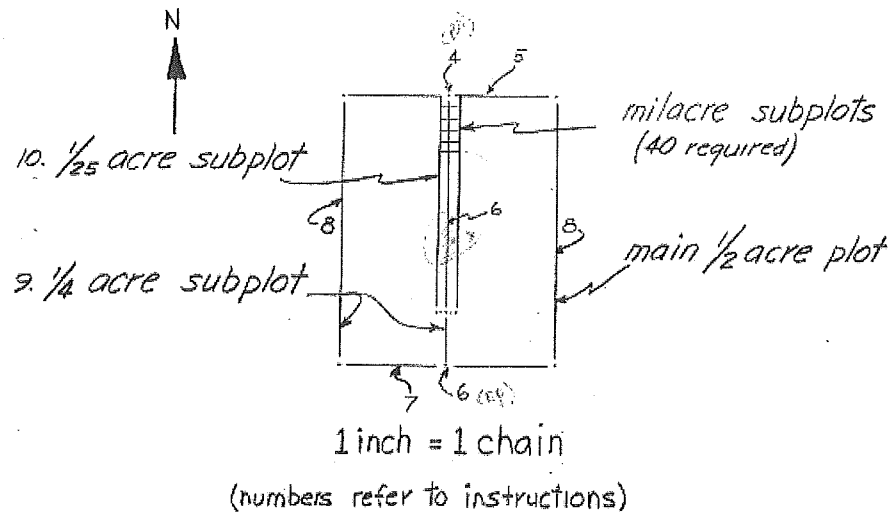


Figure 1. 1959 plot layout.

### 1989 to 2005

In 1989 the plot size was changed from a  $\frac{1}{2}$  acre rectangular plot to a  $\frac{1}{5}$  acre circular plot. The subplot measurement was changed to  $\frac{1}{20}$  acre and is now used to measure trees from 7.0" DBH to 10.9" DBH. The  $\frac{1}{100}$  acre regeneration plot is used to tally number of trees greater than 4.5 feet and less than 7.0" DBH by species and 2" DBH class.

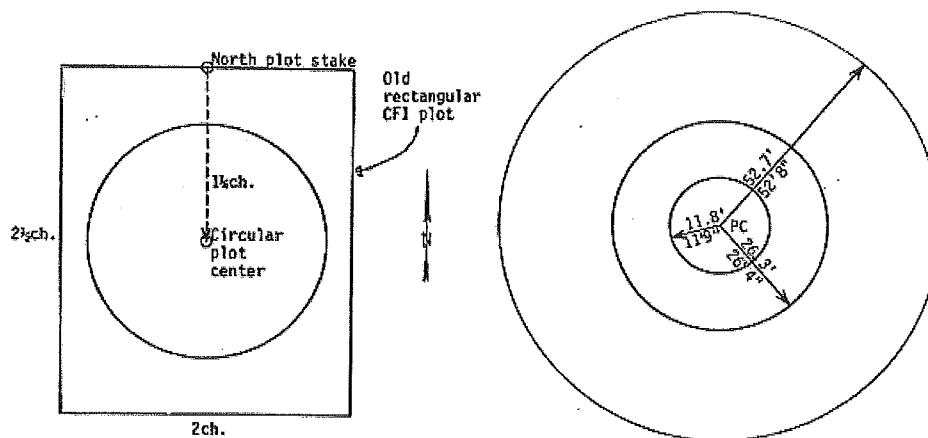


Figure 2. 1989 Plot layout

### TREE DATA

The tree data collected for trees on the main and subplot is stored in the *Trees* table in the database. Data for all the measurement cycles appear in this table; so many of the fields will be populated only for trees measured 1984 and previous, and other fields will be populated only for trees measure 1989 and later. All the possible codes for each field are not included in the table below. See the appropriate field procedures manual for a complete description of allowable codes and their descriptions.

Table 2. *Trees* Database Table

Field	1959-1984	1989-2005	Comment
Tree#	X	X	See discussion in Appendix I.
Species	X	X	Numeric codes changed in 1989. In 2005 alpha codes were added.
Status		X	Numeric code for Survivor, ingrowth, mortality, harvest, etc. Alpha codes added in 2005.
Disposition	X		Similar to status, but slightly different codes.
DBH	X	X	Recorded to 0.1" at DBH (4.5 feet). For 59-84 recorded as $\frac{1}{10}$ inch (divide by 10 to arrive at inches)
LCR	x	X	Live Crown Ratio. % of total height of tree occupied by live crown. Previous to 1989, it was measured in 1979 only.
Defect		X	Subplot only. Defect code such as catface, fire scar, fork, etc.
%defect			% deduction for loss of board foot volume from merchantable portion of tree.
Defect pre89	X		Defect codes by species.
Merch Class	X		Merchantability class. Examples include Live merch, live cull, etc.
Crown Class	X		Dominant, Codominant, Intermediate, Oppressed, Suppressed.
Vigor Class	X		Codes which describe crown length, density, width, foliage, position.
Abnormality	X		Defect codes such as scarred, dead top, leaning, crook, sweep.
height	X	X	Measured on subplot in 1959. Then remeasured in 79, 98, 99 and 2005.
10 yr RG		X	Measured for ingrowth trees
5 yr RG	X		Measured for ingrowth trees in 1959 only
Tag #		X	The tag # found at breast height. This may differ from the Tree#. See discussion in Appendix I.
Plot ID	X	X	The unique ID which relates each tree to the plot# and measurement period.
Sub Plot		X	An indication of whether the tree falls on the subplot.

## FORM NAVIGATION

A user interacts with the database by the way of "Forms". A form presents the data in the underlying tables in a (hopefully) user-friendly way. The main forms in this database are usually organized by plot or unit (more on units later). In order to move from one plot or unit to the next, you will use the navigation buttons which appear at the bottom of the form and look something like this;

Record:  1 of 141

In this example, you are viewing record 1 of 141 and the buttons allow you to move between "records". A "record" refers to a unit, plot, or some other logical grouping of data which you wish to traverse.;

The buttons are used as follows;

 First Record

 Previous Record

 Next Record

 Last Record

 new Record (if adding a plot, tree, or unit to the database)

## DATABASE ORGANIZATION & USE

When a user opens the CFI database, one is presented with the Main Menu. Here you will find a series of buttons with a description next to each button. The Data Entry/Edit button will allow you to enter or edit plot data. The Reports button will take you to a menu which allows you to choose from several different reporting options. Each of these buttons is described in the sections below. Note: In the lower left you will also notice a minimized window. You can maximize this window to access all the database tables, forms, and reports without the use of the general database menus. This is for advanced users only.)


### DATA ENTRY/EDIT

The buttons on this menu will take you to a form that allows you to enter plot and tree data. Because the type of data collected changed over the years, there are three different data entry forms; *2005 Data Entry*, *1989 and 1999 Data Entry*, and *Pre 1989 Data Entry*. The major differences between measurement periods have been described above. On these forms you will find data pertaining to the plot header, main plot and subplot trees, regeneration plot, competing vegetation (1989 and 1999 only) site trees, and reference trees. Because the casual database user will only use these forms to review plot data, or make a minor change to existing data, we will not go into further detail here.

### REPORTS

The buttons of primary interest on this report are; *Setup and Manage Units*, *Unit Summary Reports*, and *Print Reports for Individual Plots*. These three are described below. The other buttons launch uncomplicated reports which don't require further explanation.

#### Setup and Manage Units

A unit can be any collection of plots. When you create a unit, you are merely defining a group of plots from one measurement period for which you would like to carry out some analysis. No editing of plot or tree data occurs here. Use the record navigation buttons as described above to go to the unit of your choice, or to create a new unit, press the  button. Follow the steps below to create a new unit, or skip to the fourth bullet point to recalculate heights or volumes.

- Give the unit a logical name and choose the inventory cycle.
- Optionally give a THP name, owner, the type of unit, unit acres, and any notes.
- Choosing the *Add all Plots in Inventory Cycle* button will add all the plots for that measurement year (all 141 plots for 2005 for example). You may also choose the *Add individual Plot* button to add one plot at a time. As soon as you add plots to the Unit, you will notice that the box titled "Current Height & Volume Equations for this unit:" is updated. If the plots you have added to the unit use various height-diameter relationship equations or volume equations you will be alerted to this fact and asked to recalculate the values.

- Use the *Board Foot Volume Eq. Type* and the *Ht-Dbh Equation Type* radio buttons to choose the appropriate equations to use, and then press the *Estimate Heights, Calculate Volumes* button to calculate new values for all the plots in the unit. To learn more about the possible equation types, see Appendix II.
- You can also choose to calculate average site index for the plots in the unit by pressing the *Calculate Average Site* button. This will use all trees for which a height has been calculated to arrive at an average.
- To learn more about the *Export to CRYPTOS* function, see Appendix IV.
- To delete a unit, click in the vertical bar that runs the length of the form on the left side. This bar will become highlighted black and a ► will appear at the top of the bar. Hit the delete button, and answer yes to the "Relationships that specify cascading deletes . . . Are you sure you want to delete these records?" question.

### Unit Summary Reports

Here you have the possibility to create a variety of reports for the unit which you set up in the previous example. Again, use the record navigation buttons to move to the Unit of your choice. You will not be able to change any information pertaining to the unit from this form. All reports generated from this form include only trees with a DBH  $\geq 11.0$ ". Following is a description of the buttons available on this form.

### General Unit Reports

- General Unit Summary – For 1959 to 1984 data, this report lists trees per acre (TPA), basal area (BA) per acre, and quadratic mean diameter (QMD) by species. TPA, BA per acre, QMD, and gross board foot (BF) volume per acre is summarized for conifer and hardwoods. For 1989 to 2005 data, this report lists TPA, BA/acre, QMD, BF Volume/Acre Gross, BF Volume/Acre Net, Cubic Foot (CF) Volume/Acre by species, and by conifer and hardwood subtotal. The standard error is given for each of these values as well. Standard error is not give for the QMD, and net board foot volume is not computed for hardwoods.
- Plot/Species Summary Report – This report can only be generated for plots from the 1989 to 2005 measurement cycles. TPA, BA/acre, QMD, BF Volume/acre by species for each plot.
- Stand Table – TPA by 2" diameter class
- Basal Area Table – BA per acre by 2" diameter class
- Gross Stock Table – Gross Board Foot Volume per Acre by 2" diameter class
- Net Stock Table – Net Board Foot Volume per Acre by 2" diameter class. This report can only be created for the 1989 to 2005 measurement cycles.

### Growth Reports

The growth reports show change in volume between 2 consecutive measurement cycles. Though growth can be calculated from 1989 to 1999, the plot size change in



1999 causes numerous problems. See Plot Size Reconfiguration in Appendix I for a detailed explanation. Growth can be calculated by two methods. The first method computes the change in volume for each individual tree on the plot and presents an average for each species by status (survivor, ingrowth, mortality, and harvest). The second method is a hybrid of comparing individual trees and total plot volumes. This method relies partly on the first, so you must compute growth by the first method in order to carry out the second method. Before computing growth, on the growth subform in the lower right of the form, using the record navigation buttons, choose the unit that contains the plots for the time period to which you would like to measure growth. This subform will list all eligible units (units that contain plots from a measurement period directly following the one from which you are growing). Growth will only be calculated for plots found in both the "grow from" unit and the "grow to" unit.

- Unit Growth Summary Measured by comparing Individual trees – As mentioned above, this method will report for each species, the change in <sup>gross</sup> BF volume per acre per year for survivor, ingrowth, Mortality, and Harvest trees. See Appendix III for an explanation of assumptions that are made for this growth routine. When this routine is run, a text document called Growth\_errors\_xxxxtoxxxx.txt where xxx is replaced by the "from" and "to" period, is created in a folder called error\_reports residing in the same location as the database.
- Unit Growth Summary Measured by comparing total volumes for each period – Three calculation methods are presented; net increase, gross growth including ingrowth, and net growth including ingrowth. The net increase is total volume in period 2 minus total volume in period 1. The Gross growth including ingrowth is the same as above, plus the volume of mortality trees in period 1 and the volume of harvested trees in period 1. The net growth including ingrowth is the same as the first, plus the volume of harvested trees in period 1. To arrive at the volume of mortality and harvested trees, individual trees on plots are compared. The reason this must be done is that when a tree is identified as harvested or dead in Period 2, no DBH is recorded, and thus no volume can be computed. Therefore, the volume of that tree must be found in period 1. > again, all volumes in gross BF
- Growth by DBH Class – This group of buttons reports BF Volume per acre per year by 2 inch DBH Class. The report can be run for Survivor, Ingrowth, Harvest, or Mortality volume.

## Appendix I. Tree Numbering and Plot Re-Configuration Issues

There are two major issues that arise when attempting to track inventory growth and individual trees through the 1959 to 2005 measurement cycles. The first has to do with tree numbering inconsistencies, and the second with the plot size and configuration change in 1989. These are addressed below.

### ***Tree Numbering Inconsistencies***

In 1959 trees were numbered on the plot sheet, and a corresponding metal tag was placed on the tree at breast height. In subsequent years, many problems cropped up. A thorough description is given below in the section titled *Use of Tree Numbers in the Field and in the Database*.

The entire database was reviewed and every effort was made to give trees a consistent tree # through all the measurement periods. If a tree still exists on the plot in 2005, the database tree# and the metal tag at stump level coincide. Many tree numbers for trees that no longer exist on the plot were changed to avoid conflicts. The original tree # as entered originally in the left most column of the plot sheet can now be found in the *tracking\_ID* field in the database. For a list of common changes that were made see the bulleted list below.

Often a tree number was duplicated on the plot. This doesn't mean there are 2 tree #2 in the field in 2005, but that #2 was used for a tree that died in 1984 and then the #2 was used again for a new ingrowth tree in 1989. This causes problems when trying to track trees through the entire database. In the future, the cruiser should have a list of all numbers previously used on the plot to ensure that once a tree number is used, it is retired indefinitely.

### ***Plot Size Reconfiguration***

As discussed earlier in this text, the plot size was reconfigured in 1989 from a ½ acre rectangular plot to a 1/5 acre circular plot. The subplot and regeneration plot size also changed. In 1989 all trees were assigned new numbers in the field and the database. For the most part we were able to link surviving trees with their corresponding tree on the 1984 plot. However, this was not possible for virtually all the mortality and harvest trees. Also, there is a suspicious spike in trees coded as missed survivor for 1989 (348 trees compared to about 50 trees in a usual year) for which zero growth is assumed in the growth routine. For these reasons, the growth, harvest and mortality volume estimated from 1984 to 1999 is flawed and all three should be considered a very conservative (low) estimate.

### ***List of Common Changes made to Correct Tree Tracking Issues***

- Plot 08-04 the cruisers were not able to match any of the 1989 trees to the 1984 trees.
- If a tree was missed and then found the following measurement period, a tree was added in the missed period with a DBH ½ way between the two existing

measurements. The remarks field contains a comment stating "Added with estimated DBH"

- If a tree was recorded, but they failed to enter a DBH, then an estimate dbh was entered, and a remark in the remarks field of "estimated DBH added in office"
- Trees that were determined to be out of plot were deleted.
- If a tree was shown as harvested the previous period and is entered on the plot sheet a second time as harvested, it was deleted from the second period.
- For the 2005 inventory effort, Marc Jameson has asked that fused trees be treated as 2 trees. Originally, in 1999 if trees were fused, one tree was dropped, and one tree given a DBH of the sum of both. This was changed in the following manner: For 1999, both trees were reassigned the DBH they had in 1989. Then in 2005 they were measured with a ½ diameter. This occurred on plot 09-05, 10-07, 11-04, 13-03, 13-04, and 23-01
- For pre-1989 plots, a duplicate tree record existed for some trees, one with a merchantability class of 7 (mortality tree) and the second with 8 (salvable dead tree). The tree record with merchantability class 8 was deleted.
- When a tree number is duplicated, the dead or harvested tree (which no longer exists on the plot) is given a new arbitrary # in the database. This arbitrary number is guaranteed not to be a duplicate tree number with any tree that existed at any time on that plot. However, it may be a tree number that was previously used for an already renumbered tree. This is very confusing, but here is an illustration. First, it should be pointed out that in 1989, when the plot size was reduced, that all trees got a new number in the field (and thus the database). Lets say tree #2 which existed from 1959 to present was renumbered in 1989 to tree #30, and still exists as tree #30 in the field. Then all tree #2s for 1984 and previous in the database will be given the new tree #30. Now, on the same plot there is another tree number conflict, and a tree that no longer exists in the field in 2005 needs to be assigned some arbitrary #. Well, the #2 might be assigned to this tree from 1959 to 1984 when it was harvested.

### ***History of Tree Numbers as used in the field and in the database.***

Below, *physical#* refers to the physical number printed on the metal tag out in the field. *Tree# field* refers to the tree number written on the left most column of the plot sheet. *Tag field* refers a field in the database which was added to hold the physical number in the field at DBH if it differed from the *tree#* field.

1959

The tree number is placed at DBH.

1964 and 1969

If a *physical#* changed, most often the *Tree#* field is updated, and a remark such as "was #xxx" or "previously #xxx" is given. However, there are some cases where the surveyor put a new *physical#* on the tree, but left the *tree#* field as is, and the only record of the change is a comment in the remarks field such as "new tag#xxx". Then,

in the following measurement cycle the *tree#* field is changed to match the "new tag#xxx" which also corresponds to the physical #.

1974

There are 90 trees that have a value in the *tag* field of the database. These are trees whose physical# and the number in the *tree#* field has changed. If the remark on the paper plot sheet said "tag# xxx" then the data entry person put the previous physical# (*tree#* field) of the tree in the *tag#* field. However, there are also many trees with a remark with the same intent, but worded slightly differently such as "was #xxx" or "previously #xxx" and in this case the old physical# was not placed in the *tag#* field.

1979

In 1979 it was decided to retain the original # in the *tree#* field as a tracking# and not to update it to any new physical# in the field. The intent was to have a permanent tracking number in the *tree#* field. 337 trees had their physical# change and this value is entered into the *tag#* field.

1984

As before, the original # is retained in *tree#* field, and *tag#* field has actual # on tree.

1989

½ acre rectangular plots were changed to 1/5 acre circular plots. For most plots, the trees are given an entirely new number which is entered into *tree#* in the database and is also placed at stump height in field. In the remarks column can be found the reference to the physical dbh tag out in the field. This is the only number that will allow you to trace the tree back to 1984.

1999

As in 1989, the *tree#* field continues to correspond to the physical metal tag at **stump** height. The DBH tag# is now placed into the *tag#* field. With new ingrowth, a tree is given identical physical metal tags at stump and DBH height.

2005

As in 1999, except that if a physical DBH tag is missing or grown over, it is replaced with the number that corresponds to the *tree#* field and the physical stump #.

## Appendix II. Equations for Height & Volume Estimation

This Appendix defines the forest-wide equations that can be applied in the CFI database. For tree heights in the CFI database, for the 1989 and later measurements, the user has the option to apply the CFI derived equations (as defined in the bulleted list below), or the FRI derived equations. For board foot volumes in the CFI database, the user has the option to apply the 1959 or the 1989 volume equations for any measurement year. There is only one choice for cubic foot volumes. For the purpose of reporting formal CFI inventory estimates, and in the master CFI database as distributed to new users (i.e. you just got the database from JDSF staff and haven't recalculated the heights or volumes), the following equations are used;

- Height
  - For 1959 to 1984 – The 1959 Young Douglas-fir (for young and old DF) and Young Redwood (for young Redwood only) equations, and the 1989 equations for all other species.
  - For 1989 to 1999 – The 1989 equations are used for all species
  - For 2005 – The 2005 FRI equations are used for all species.
- Volume
  - The 1989 volume equations as defined in the section titled *1989 Board Foot Volume Equations* are used.

### HEIGHT-DIAMETER EQUATIONS

#### 1959 CFI

We don't have record of the height-diameter equations that were originally developed from 1959 height trees by early JDSF staff. Equations were developed in 2007 for YR and YD from the 1959 height trees. These are given below.

Equation source: local derivation based upon 1959 CFI

Equation form:  $H = 4.5 + \exp(b_0 + b_1 * DBH^{b_2})$

<u>Species/Age</u>	<u>Height/Diameter Equation</u>
young redwood	$4.5 + \exp(5.1146 + -15.2348 * DBH^{-1.0892})$
young Douglas-fir	$4.5 + \exp(6.7285 + -4.4136 * DBH^{-0.2664})$
OG Douglas-fir	same as 1959 Young Douglas-fir

#### 1964 through 1984 CFI:

No record exists of any equations developed during this time.

## 1989 CFI and IFI:

Equation source: local derivation based upon 1989 CFI and IFI (VESTRA)

Equation form:  $H = 4.5 + \exp(b_0 + b_1 * DBH^{b_2})$

Species/Age	Height/Diameter Equation
young redwood	$4.5 + \exp(5.411 + -7.672 * DBH^{-0.731})$
OG redwood	$4.5 + \exp(7.393 + -5.482 * DBH^{-0.218})$
young Douglas-fir	$4.5 + \exp(5.754 + -5.624 * DBH^{-0.588})$
OG Douglas-fir	same as Young Douglas-fir
grand fir	$4.5 + \exp(6.696 + -4.810 * DBH^{-0.309})$
other conifers	$4.5 + \exp(5.340 + -6.151 * DBH^{-0.696})$
hardwoods	$4.5 + \exp(4.390 + -9.469 * DBH^{-1.307})$

## 2005 FRI:

Note: All equations are new for 2005 except the OG redwood.

Species/Age	Height/Diameter Equation
OG redwood	$4.5 + \exp(7.393 + -5.482 * DBH^{-0.218})$ same as 1989 CFI
young redwood Site Class I & II	$4.5 + \exp(5.522 + -9.757 * DBH^{-0.789})$
young redwood Site Class III	$4.5 + \exp(6.066 + -5.785 * DBH^{-0.439})$
young redwood Site Class IV	$4.5 + \exp(5.697 + -6.491 * DBH^{-0.563})$
young Douglas-fir Site Class I & II	$4.5 + \exp(5.631 + -8.028 * DBH^{-0.764})$
young Douglas-fir Site Class III	$4.5 + \exp(6.497 + -5.011 * DBH^{-0.335})$
young Douglas-fir Site Class IV	$4.5 + \exp(6.052 + -5.927 * DBH^{-0.486})$
OG Douglas-fir Site Class I & II	same as Young DF Site Class I & II
OG Douglas-fir Site Class III	same as Young DF Site Class III
OG Douglas-fir Site Class IV	same as Young DF Site Class IV
grand fir	$4.5 + \exp(5.638 + -7.336 * DBH^{-0.711})$
Bishop Pine	$4.5 + \exp(5.188 + -12.442 * DBH^{-0.991})$
Western Hemlock	$4.5 + \exp(5.129 + -5.779 * DBH^{-0.817})$
Sitka Spruce	same as Western Hemlock
other conifers + cypress*	$4.5 + \exp(6.921 + -5.904 * DBH^{-0.266})$
Tanoak	$4.5 + \exp(4.476 + -7.261 * DBH^{-1.114})$
Madrone	$4.5 + \exp(4.269 + -16.948 * DBH^{-1.724})$
Chinquapin	$4.5 + \exp(4.542 + -37.279 * DBH^{-1.760})$
Alder	$4.5 + \exp(4.833 + -5.480 * DBH^{-0.924})$
Maple	same as Tanoak
Live Oak	same as Tanoak
Other hardwoods†	same as Tanoak

\*One equation was derived by combining OC and Cypress trees.

†Other hardwoods Includes: Willow, Eucalyptus, Waxmyrtle, and Bay

## VOLUME EQUATIONS

### 1959 Board Foot Volume

These local volume equations may have been developed by Lee Wensel in 1961 using the 1959 CFI data. The major species have equations dependent on site class. Site class is assigned to the plot from the NRCS soil polygon site class.

When applied to 1989 and future CFI measurements, the following equation substitutions are made.

Other Conifer uses Shore pine equation

Sitka Spruce uses the young growth white fir equation

Other hardwood uses the canyon live oak equation

All grand fir is treated as young growth grand fir

Equation form:  $V = a + b \cdot \text{DBH} + c \cdot (\text{DBH}^2)$

Common Name	Site	a	b	c
Young-Growth Douglas-fir	I,II	156.087	-33.6927	2.47545
Young-Growth Douglas-fir	II-IV	139.386	-29.308	2.03223
Old-Growth Douglas-fir	-	1293.277	-110.7644	3.3981
Young-Growth Redwood	I,II	166.09	-31.2456	1.82285
Young-Growth Redwood	III-IV	142.13	-26.8349	1.58044
Old-Growth Redwood	-	362.238	-49.1316	2.00178
Shore Pine	-	217.061	-38.0766	2.01718
Bishop Pine	-	217.061	-38.0766	2.01718
Old-Growth Grand Fir	-	1293.277	-110.7644	3.3981
Grand Fir	-	-143.866	-4.6394	1.93271
Western Hemlock	I,II	166.03	-31.2456	1.82285
Western Hemlock	III-IV	142.13	-26.8349	1.58044
Nutmeg	-	217.061	-38.0766	2.01718
Cypress	-	217.061	-38.0766	2.01718
Red Alder	-	366.98	-58.2037	2.61454
Bigleaf Maple	-	78.44	-14.4223	0.8662
Willow	-	366.98	-58.2037	2.61454
Live Oak	-	163.337	-23.7085	1.09907
Tan Oak	-	-25.431	-3.6834	0.65936
Pepperwood	-	326.409	-45.4436	1.70399
Chinquapin	-	-25.431	-3.6834	0.65936
Pacific Madrone	-	-143.437	10.0495	0.2903
Waxmyrtle	-	78.44	-14.4223	0.8662
Eucalyptus	-	366.98	-58.2037	2.61454

### 1989 Board Foot Volume

Conifer Equation source (except OG Redwood, board feet scribner to 6" top diameter inside bark [DIB] and total height), locally calibrated to JDSF fall-and-buck data in 1989:

Research Note No. 9, Redwood Cooperative Growth and Yield Project (Krumland and Wensel, 1978) Also Published in Bulletin 1907 Division of Agricultural Sciences, University of California (Krumland & Wensel, 1983)

Old Growth Redwood equation: Derived at JDSF in 1980 and referred to as version 2 of our all-age east-end redwood volume equation. (From handwritten note by John Griffen dated 12/89)

Hardwood equations: From Pillsbury & Kirkley, USDA Forest Service Research Note PNW-414, 1984. Where their equations included an indicator value J. Griffen assumed 2 for madrone and 4 for live oak (other hardwoods). The equations were adjusted from cubic to board feet by the factor 3.14 from the 1984 JDSF CFI. (From handwritten note by John Griffen dated 12/89)

Equation form:  $V = b_0 * (D^{B1}) * (H^{B2}) * J$  (all except old redwood)

note: "J" is a correction factor for use on JDSF, thus these equations are referred to as locally calibrated to JDSF fall-and-buck data in 1989. In the equations below,  $b_0$  and J have been combined by multiplication.

Species/Age	Volume Equation
OG Redwood	$\exp(-6.2233 + 1.6117 * \log(\text{DBH}) + 1.6021 * \log(H))$
OG Douglas-fir	same as Douglas-fir
young redwood	$.0003288 * \text{DBH}^{2.012} * H^{1.664}$
young Douglas-fir	$.0004714 * \text{DBH}^{1.725} * H^{1.809}$
grand fir	$.00009784 * \text{DBH}^{1.767} * H^{2.128}$
western hemlock	same as grand fir
Bishop pine	same as grand fir
other conifers	same as young redwood
tanoak	$.0007933 * \text{DBH}^{2.3095} * H^{1.2107}$
Pacific madrone	$.002524 * \text{DBH}^{1.7264} * H^{1.2646}$
other hardwoods	$.003747 * \text{DBH}^{2.2444} * H^{0.8136}$

## 1984 Cubic Foot Volume

Conifer Equation source (to 6" top diameter inside bark [DIB] and total height):

Research Note No. 9, Redwood Cooperative Growth and Yield Project (Krumland and Wensel, 1978) Also Published in Bulletin 1907 Division of Agricultural Sciences, University of California (Krumland & Wensel, 1983)

Hardwood equation source:

USDA Forest Service Pacific Northwest Research Station, Research Note PNW-414, Pillsbury & Kirkley, 1984. Although the publication does have equations for Maple, Chinquapin, and Bay Laurel, the Coast Live Oak equation is used for all other Hardwoods other than Tanoak and Madrone in order to stay consistent with the Board Foot volume equations which were previously.

Equation form:  $V = b_0 * (D^{B1}) * (H^{B2})$

Note: In contrast to the Board Foot Volume equations, the cubic foot equations have not been locally calibrated.

Species/Age	Volume Equation
OG Redwood	same as Young Redwood



OG Douglas-fir	same as Douglas-fir
young redwood	$.0006605 * DBH^{1.833} * H^{1.129}$
young Douglas-fir	$.0009947 * DBH^{1.625} * H^{1.366}$
grand fir	$.0003982 * DBH^{1.709} * H^{1.502}$
western hemlock	same as grand fir
Bishop pine	same as grand fir
other conifers	same as young redwood
tanoak	$.000577497 * DBH^{2.19576} * H^{1.14078}$
Pacific madrone	$.0025616425 * DBH^{1.99295} * H^{1.01532}$
other hardwoods	$.0024574847 * DBH^{2.53284} * H^{0.60764}$

## Appendix III. Growth Routine Assumptions

In the explanation below, the trees are grown from period 1 to period 2. P1 refers to the tree in period 1 and P2 refers to the tree in period 2.

In general, all harvest and mortality calculations can be considered to be on the conservative side. When TPA, BA, and volume are calculated for a tree which died or was harvested, the calculations are made based on the diameter of the tree at P1. In theory, one could assume on average that the tree reached a diameter and volume half way between the two measurement cycles. However, because a cruiser in P2 can no longer measure the DBH of a stump (and the DBH of mortality trees may be unreliable), the P1 DBH is used.

A few other situations also result in conservative estimates. If a period 2 tree has status of harvest or mortality, but cannot be matched to a P1 tree, no volume is computed. For ingrowth harvest and ingrowth mortality trees, no volume is computed. If a tree is found in P2 that should have been measured previously (missed survivor), no growth is computed.

Sometimes a tree in P1 has a DBH between 7.0 and 10.9 inches, and then in P2 its DBH is greater than 11 inches. In this case, the P1 tree has an expansion factor corresponding to the subplot and the P2 tree has an expansion factor corresponding to the main plot. When this happens, the TPA, BA per acre, and volume per acre is higher in P1 than in P2 even though the tree exhibited growth. This is a fairly rare case and will only affect calculations if looking at an individual plot.

Below is a list of assumptions that is made when calculating growth.

- If P1 status is live (1,2,91) and P2 status is ingrowth or missed tree (2,91) then it is assumed P2 status was meant to be live 1 and tree is treated as live and growing
- If P1 is harvest or mortality (3,23,93,4,24,94) and tree exists in P2, the P2 tree is assumed in error and no growth is computed.
- If P1 tree exists in P2, but P2 tree has status of ingrowth mortality 23 or missed mortality 93, then P2 tree is assumed to have status of mortality
- If P1 tree exists in P2, but P2 tree has status of ingrowth harvest 24 or missed harvest 94, then P2 tree is assumed to have status of harvest
- If P1 Tree with live status (1,2,91) is unmatched in P2 then mortality is assumed\*
- If P2 tree is unmatched in P1 and has live status of live 1, it is treated as ingrowth
- If P2 tree is unmatched and has status of Ingrowth mortality 23 or ingrowth harvest 24 then it is not processed
- If P2 tree with status missed tree 91 is unmatched in P1, tree is not processed/ no growth calculated
- If P2 tree with status of harvest/mortality is unmatched in P1, tree is not processed/no growth calculated

- If either P1 or P2 tree has missing tree number, status, or dbh then tree cannot be processed. NOTE: if P1 tree is not found in P2 in database, then mortality is assumed. However, if the P2 tree still exists in the database (usually with no DBH) but with a note in remarks that it couldn't be found, then the tree is not processed.

\*Note: In 1989 the plot size was changed from a 1/2 acre plot to a 1/5 acre plot. It follows that many trees on the 84 plot will not be found on the 89 plot. Therefore, for the 84 to 89 growth routine, all 1984 trees not found in 1989 are unprocessed, rather than the normal routine of assuming that they are mortality trees. Also, in 1989 most stumps do not have corresponding tree numbers. Therefore, the harvest volume is underrepresented because the 1984 volume cannot be retrieved to calculate harvest volume. Also, in 1989 there are 348 trees (about 11% of total) that are labeled as missed survivor. Many of these trees should probably be ingrowth or survivors. However, since they are listed as missed survivors, zero growth is assumed, thus resulting in a conservative estimate of growth.

## Appendix IV. Export to CRYPTOS

CRYPTOS (Cooperative Redwood Yield Project's Timber Output) is a growth simulation program for the north coast developed by UC Berkeley. CRYPTOS export is only possible for plots measured in 1989 and later. Live trees with DBH greater than or equal to 7 inches are exported. Trees with a DBH  $\geq 7$ " and  $< 11$ " will have a per acre expansion factor of 20 because they are found on the subplot. Trees with a DBH  $\geq 11$ " will have an expansion factor of 5. Trees from the regeneration plot are not exported to the CRYPTOS stand table. Therefore, if you plan to grow these exported CRYPTOS stands for more than a few growing periods you may wish to consider adding some regeneration trees. Bishop pine and Cypress are exported with CRYPTOS species code of "other hardwood". Grand fir, Hemlock, and Sitka Spruce are exported as "other conifer". Default live crown ratio of 35 is given for trees with missing LCR. The export routine creates a text file called <PlotID>.sd for each plot where <PlotID> is the internal autonumber Plot ID of the plot. A text file called <UnitID>ZER.TXT will list any plots with no trees.

### ***Site Index used for CRYPTOS export***

CRYPTOS requires a 50-year Site Index to be written to the header of each exported plot. Site Index was derived from the 2005 Forest Resource Inventory (FRI) and the *Site Class* GIS layer. The FRI was an intensive forest-wide inventory on a 5 by 20 chain grid totaling almost 5000 plots. The *Site Class* GIS layer is based on soil type polygons and redwood and Douglas-fir site index published by the Natural Resource Conservation Service (NRCS). Fifty year site index was calculated for each FRI site tree using the 2005 Krumland & Eng King-Prodan Model form equation (K&E). FRI plots which fell into an individual soil polygon in the *Site Class* GIS layer were grouped together. An average 50 year site index was calculated for each grouping. All CFI inventory plots that fell into this soil polygon were assigned the averaged FRI site index.

If a soil polygon had no 2005 FRI plots with site trees that fell within it, then an average of the site index of all other soil polygons with the same soil complex type was assigned to plots that fell within this soil polygon.

If neither of the above methods could be used then, the 100 year site Index published by the NRCS for the soil complex was converted to 50 year site index with the K&E equation. For the few remaining soil polygons for which none of these options was possible, site class 4 is assumed, the midpoint of the corresponding 100 site index is found in the forest practice rules, and this is converted to 50 year site index using K&E.

Tan oak and other hardwoods are assigned a site index of 75, Alder a site index of 100, Old Growth redwood the Redwood site, and all remaining species are assigned the Douglas-fir site index.

## Appendix V. Growth Calibrated by Growing Seasons

For the 1989 to 1999 and the 1999 to 2005 growth intervals, the elapsed time between measurements was calibrated by growing seasons. Because trees tend to grow more in the months of May through August, the growth time should be calibrated according to what time of year the plot measurements were taken. The effective elapsed time is used for both growth calculation methods (comparing individual trees or comparing total plot volumes). A table called *ElapsedTime* was created in the database which has the effective elapsed time for 1989 to 1999 and 1999 to 2005.

The effective elapsed time was calculated as follows. The example given is for the 1999 to 2005 measurement interval. First, the time that elapsed between measurements for each plot was calculated. Next, the time from the 1999 measurement to the end of 1999 is calculated. Then, using the seasonal growth derived from State Forest Note published in January 1961, the percentage of a year's growth attributed to this fractional period is calculated. Then, the time from the beginning of 2005 to the plot measurement in 2005 is calculated. Then the percentage of a year's growth attributed to this fractional period is calculated. Finally, the effective growth periods are calculated by adding the 5 total years plus the two effective fractional years.



## In this folder

JSF CFI MASTER.mdb

!CFI\_General\_overview.doc

CFI\_volume-1959to2005.xls

Error\_reports folder

Explanation of Database Queries.doc

JDSF Volume & HT-DBH eqns.doc

JDSF CFI Database Programmer's Guide.doc

Site.doc

Site.xls

The master database that contains all CFI data. See the general overview for further description.

A general overview of the CFI database for the casual user. See the JDSF CFI Database Programmer's Guide.doc for further description. this excel file graphs total volume and harvest volume from 1959 to 2005. The document does not state who created this file, where the numbers come from, and which equations they are based on. They do not reflect the current volumes in the CFI.

This folder contains reports automatically generated each time the growth routine is executed in the CFI database. The report lists all trees which did not have a logical match in the "grow from" and "grow to" cycle, and the type of error that caused the problem. The **archived** (archived 3/2007) folder contains versions of all the growth error reports from 1959 to 2005, with explanations of each error. See the readme in the archived folder for further explanation.

a partial explanation of database queries used when creating the database. a document compiled to summarize the ht-dbh equations and volume equations to be used in the CFI and the 2005 FRI.

This guide describes the forms, queries, and reports in the database from the prospective of a programmer who needs to make changes to the database.

A document that describes the various methods used to arrive at site class and site index for FRI and CFI plots. This document describes each method as well as the contents of site.xls.

an excel spreadsheet that shows the calculations used to assign site class and 50 year site index to soil polygons which did not have a published site index. Site Class is needed for assigning plots to the correct Ht-DBH curve for YR and YD. 50 year site index is needed for exporting plots to CRYPTOS growth modeling stand tables.

## In 1999to2005GrowthAnalysis folder

This folder contains files pertaining to the test where 1999 CFI data was grown using CRYPTOS and then compared to 2005 CFI data.

CFI\_CRYPTOS\_Analysis-Abstract.doc

Growth-period-calculations.xls

JSF\_CFI Cryptos growth.mdb

Seasonal\_growth.xls

State-Forest-Note6.pdf

This word document contains a brief description of the methods used.

The excel spreadsheet where the effective growth period was calculated according to the adjustments delineated in seasonal\_growth.xls

This is a copy of the CFI database. The cryptos export routine was modified to export cryptos files with the adjusted growth period.

The spreadsheet showing seasonal adjustments as derived from the research paper

This is the research paper that measured seasonal growth.

## In Archive Folder

1989and99\_incomplete\_edit.doc

Original Plot Sheets scanned

1999CFI\_original\_files

JSF-CFI-199.mdb

JSF CFI 1989.mdb

This document contains an incomplete record of edits made to tree records. It was maintained early on when cleaning up the 1989 and 1999 tree records, but was not maintained due to the huge amount of edits that were ultimately made to the tree table. This folder contains all the original plot sheets from 1959 through 1999 (2005 has not yet been completed) scanned as .png image files.

The original excel files used to create the 1999 CFI Access database

The 1999 CFI database as created in May 2005 before being imported into CFI master Database.

sent by Helge Eng June 8, 2005. This data was entered by student interns the same month. I performed some data validation – allowable species code, allowable status

code, missing or <7 or very high dbh checked before importing into the CFI Master Database.

**JSF CFI 1958\_through\_1979.mdb** and **JSF CFI 1984.mdb** are access databases sent by Helge Eng in May 2005. These two databases were added to JSF CFI MASTER.mdb.

**JSF CFI Master <date>.mdb** backup of the master database created on <date>.

**Mtn Home CFI.mdb** Tim Robards Mountain Home database used to copy reports and queries for the JSF CFI database.

### **In Field Instructions Folder**

**1959\_CFI\_field\_instructions.pdf** The 1959 field instructions. Split into 2 parts only because scanning was interrupted.

**1999\_final\_specs.doc** 1999 field instructions.

**2005\_CFI field instructions v2-1** 2005 field instructions.

### **In Ht-DBH-Equations Folder**

This folder contains forestwide Ht-Dbh equations developed from the 1959, 1999, and 2005 CFI data for redwood and Douglas-fir. The 1999 and 2005 equations were almost identical to the 1989 CFI equations. Because of this, these equations were not added to the CFI database. This means that if a user chooses to apply the "CFI" equations to the 1999 or 2005 data, the 1989 equations will be applied. If a user chooses to apply "CFI" equations to the 1959 to 1984 data, the 1959 YR and YD equations are used in combination with the 1989 equations. See the **JDSF Volume & HT-Dbh eqns** word document for further explanation.

### **In Reports Folder**

This folder contains the reports that are created from the CFI database exported to word document format. The archive folder contains previous versions of the reports that were created before significant improvements were made to the CFI data.



# GIS Layer Metadata

## Inventory Plots

NAME: CFI

FEATURE TYPE: POINT

SOURCE: DIGITIZED BY VESTRA UPDATED BY SEBASTIAN ROBERTS AT JDSE

MINIMUM MAPPING UNIT: 1:24000

AREAL EXTENT: JDSE

DATE OF LAST UPDATE: 1/2006

### ATTRIBUTE ITEMS:

ITEM NAME	INPUT WIDTH	OUTPUT WIDTH	DATA TYPE	DECI MALS	DESCRIPTION
PLOTNUM	5	5	I	-	INVENTORY PLOT NUMBER
PLOTSUFF	1	1	C	-	
STATUS	1	1	C	-	? (VESTRA ATTRIBUTE)
BLACKHOLE	4	8	B	-	? (VESTRA ATTRIBUTE)
COMMENT					

### NOTES

The CFI inventory plots were extracted from a GIS layer called invplt\_1. There is no documentation as to what source data was used to digitize the CFI plots. Accuracy of plot location is unknown. About 8 plot locations were corrected in 2005 at the request of forestry aides who had installed the plot. Those that were moved can be identified in the COMMENT field.

**PLOTSUFFIX IS BLANK EXCEPT FOR THE FOLLOWING EXCEPTION:** Plot suffix for new CFI plot installed 1999. This is plot 1103 with suffix "b". This plot was installed because the original plot could not be located.

CONTACT: Jackson Demonstration State Forest GIS Specialist, (707) 964-5674

### COORDINATE SYSTEM DESCRIPTION

Projection	UTM	
Units	METERS	Datum NAD83
Parameters:		
false easting (meters)		500000.00000
false northing (meters)		0.0000

## COMPARING CRYPTOS GROWTH TO CFI MEASURED GROWTH

The 1999 CFI data was grown to 2005 using CRYPTOS growth modeling program, and the results of the growth routine were then compared to the 2005 CFI data to determine if the modeled growth is in line with the measured growth.

The first step is to calculate the total number of years that each plot should be grown in CRYPTOS to match the time elapsed between actual plot measurements. Because trees tend to grow more in the summer months, the growth time must be calibrated according to what time of year the plot measurements were taken. In 1961 JDSF staff measured the seasonal growth of 15 douglas-fir and 12 redwood trees. The data from this paper was used to create a table listing the percentage of the years growth that can be attributed to each 2 week period. The procedure used to apply this to the CFI 1999 to 2005 measurement interval is described below.

First the time that elapsed between measurements for each plot was calculated (Grow-period). Then the time from the 1999 measurement to the end of 1999 is calculated (time to 2000). Then using the seasonal growth data, the percentage of a years growth attributed to this fractional period is calculated (prcnt-grow-to-2000). Then the time from the beginning of 2005 to the plot measurement in 2005 is calculated (time past 12/31/2004). Again, the percentage of a years growth attributed to this fractional period is calculated (in field prcnt-grow-past-2004). Finally, the effective growth periods are calculated by adding the 5 total years plus the two effective fractional years (effective-periods)

The effective growth period described above is added as a "growth period adjustment" to each Cryptos stand description file at line 1. A CRYPTOS growth period usually equals 5 years. CRYPTOS will use this growth period adjustment value to change the growth period the first time a stand is grown. See *Chapter IX Advanced Topics* in the CRYPTOS manual for a complete description.

Using CRYPTOS, the stands are all grown one period (with each plot adjusted as described above) using the batch commands file grow.cm. No parameters are adjusted (mortality is left on, record quintupling is left on). One 1999 plot had no trees.

Then the CRYPTOS utility *Yield averager* is used to average the individual plot yield files. One no tree plot is included into the yield averager summary. The summary reports the yield after 1 complete period (5 years) plus the partial period. The partial period average for all the plots is 6.26 years elapsed. **The total conifer volume increase divided by 6.26 years equals 1,027 board feet per acre per year. If you only consider the first 5 years of growth then total conifer volume growth is 1,050 board feet per acre per year.**

**The basal area increment for conifers is 2.5 square feet per acre per year, and for hardwoods the increment is 0.35 square feet per acre per year over the 6.26 years.**

## How Site Class was derived

The 2005 FRI height-diameter equations for YD and YR were developed for three site class groupings; SCI&II, III, and IV. Plots were assigned to a grouping by selecting all plots that fall within NRCS soil polygons of that particular Site Class. There were a few NRCS soil polygons that did not have a published site Class for YD and/or YR. These Site Class values were assigned as delineated in the excel spreadsheet site.xls. These site class updates were not added to the sitecl\_1 GIS layer, but rather are only found in the FRI and CFI database. The field YD\_SC-source and YR\_SC-source in the FRI and CFI databases lists the source of the site class for those fields that had site class assigned. The sources are as follows

1. *Conversion from RW SC.* The Big River soil complex which appears on the forest in several river bottom locations has a site class of 1 for Redwood. This siteclass was assigned to Douglas-fir as well.
2. *FRI Site Trees.* Using the Krumland & Eng 2005 Site Index equations, 100 year site index was derived from site trees that fell within this soil complex. The site index values were averaged to arrive at one site Index for the complex. This 100 year site index was converted to siteclass using the Site Classification table found in the Forest Practice Rules Handbook Subchapter 7 Article 4.
3. *Site class IV assigned.* Site Class IV was assigned to these soil units because they are found in the pygmy and cypress areas and on 2 small steep south facing chaparral areas.

## How Site Index was derived

The 50 year site index was calculated to facilitate export of forest inventory data to CRYPTOS growth modeling program which calls for a 50 year site index. **Method B below is used to calculate site for redwood and Douglas-fir for CRYPTOS export** (tanoak and other hardwoods are assigned a site index of 75, alder = 100, and all remaining species are assigned the Douglas-fir site index for the plot). It was decided that three methods would be used to calculate Site index, and the database user could customize the database if he/she prefers to use a different site index calculation method of CRYPTOS export or other analysis. The methods are as follows;

- A) assigning site to plots based upon weighted average Natural Resources Conservation Service (NRCS) soil/site estimates for individual soil types within soil complexes
- B) assigning site to individual NRCS soil POLYGONS based upon Site Index calculated from 2005 FRI site trees (average of site by species for all plots falling within a polygon).
- C) assigning site to plots based upon nearest FRI plot with site tree estimates.

### A) Site index based on NRCS soil complex

The 50 year site index was calculated only for soil polygons that are found within the forest. A 100 year site index for YR and YD exists for most soil complexes in the site class GIS layer (For more information on the source of the 100 year Site Index see the documentation of the sitecl\_1 GIS layer). For most soil complexes, the 100 year site index is converted to 50 year site

index as in step 1 below. If the soil complex does not have a 100 year site index, then a series of alternatives is used as in 2,3,4 below. The SI50Source field in the attribute table in the GIS layer as well as the table in the FRI and CFI inventory database lists the method that was used. The methods are described here;

1. **K&E2005 eq used to convert SI100 to SI50.** For those soil polygons that had a DFIR 100SI and/or a RW 100SI, the 2005 Krumland & Eng King-Prodan Model Form equation was used to convert the 100SI to 50SI. (The vast majority of the forest falls in this category)
2. **FRI 2005 Site Trees.** Those polygons that had no DFIR 100SI and/or RED100SI, then if a 2005 Forest Resource Inventory plot with site trees falls within that soil type, then the average 50SI was calculated for all plots within the soil type using the K&E2005 equations.
3. **K&E2005 Intra species conversion from YR SI50** The Big River soil type had a published RW 100SI. The RW50SI was calculated as in 1 above. The DFIR 50SI was calculated using a conversion function from K&E 2005 which converts RW 50SI to DF 50SI.
4. **SC4 Assumed, 100SI midpoint . . .** Those polygons that had no DFIR 50SI and no RW 50SI and no FRI 2005 inventory plots with site trees, Site Class 4 was assumed (these plots almost entirely fall within the western boundary of the forest within Pygmy areas) and the midpoint of the corresponding 100SI range was used from the Forest Practice Rules Subchapter 7 Article 4 1060 table. This 100SI was converted to 50SI using the K&E 2005 equations.

## **B) Site index based on FRI site trees within NRCS soil polygons**

Fifty year site index was calculated for each 2005 FRI site tree using the 2005 Krumland & Eng King-Prodan Model form equation. Plots which fell into an individual soil polygon in the sitecl\_1 GIS layer (based on NRCS soil polygons) were grouped together. An average 50 year site index was calculated for each grouping. All CFI and FRI inventory plots that fell into this soil polygon were assigned this average site index.

If a soil polygon had no 2005 FRI plots with site trees that fell within it, then an average of the site index of all other soil polygons with the same soil complex type was assigned to plots that fell within this soil polygon.

If a soil polygon had no 2005 FRI plots with site trees that fell within any soil polygons of the same soil complex, then Site index was assigned as above, using method 1, then 3, then 4.

## **C) Site index based on closest plot with site trees**

Fifty year site index was calculated for each site tree using the 2005 Krumland & Eng King-Prodan Model form equation. If a plot had two site trees of the same species, then these two were averaged to arrive at one site index for the plot. For the remaining plots, a GIS was used to find the closest

plot with a site tree, and the site index from that plot was assigned. This exercise was repeated for both the 2005 FRI and 2005 CFI and for both YR and YD.

Equations used to calculate site for YR and YD

YRSI50:  $4.5 + 50^{1.089} / (-0.2131 + 203.4 * ((([TREE]! [AGE] ^{1.089}) / ([TREE]! [THT] - 4.5) + 0.2131) / (203.4 + [TREE]! [AGE] ^{1.089})) + ((([TREE]! [AGE] ^{1.089}) / ([TREE]! [THT] - 4.5) + 0.2131) / (203.4 + [TREE]! [AGE] ^{1.089})) * 50^{1.089})$

YDSI50:  $4.5 + 50^{1.221} / (-0.8755 + 402.8 * ((([TREE]! [AGE] ^{1.221}) / ([TREE]! [THT] - 4.5) + 0.8755) / (402.8 + [TREE]! [AGE] ^{1.221})) + ((([TREE]! [AGE] ^{1.221}) / ([TREE]! [THT] - 4.5) + 0.8755) / (402.8 + [TREE]! [AGE] ^{1.221})) * 50^{1.221})$

Procedure to find closest plot with site for each species in the GIS.

Note: For an FRI plot with no site trees, only FRI plots were used to find the closest plot with a site tree (there could be a few rare cases where a CFI plot would have been closer, but this was neglected). For a CFI plot with no site trees, again only FRI plots were used to find the closest site tree (in all cases, an FRI plot with site tree was always closer than another CFI plot).

FRI procedure (example shown using YD)

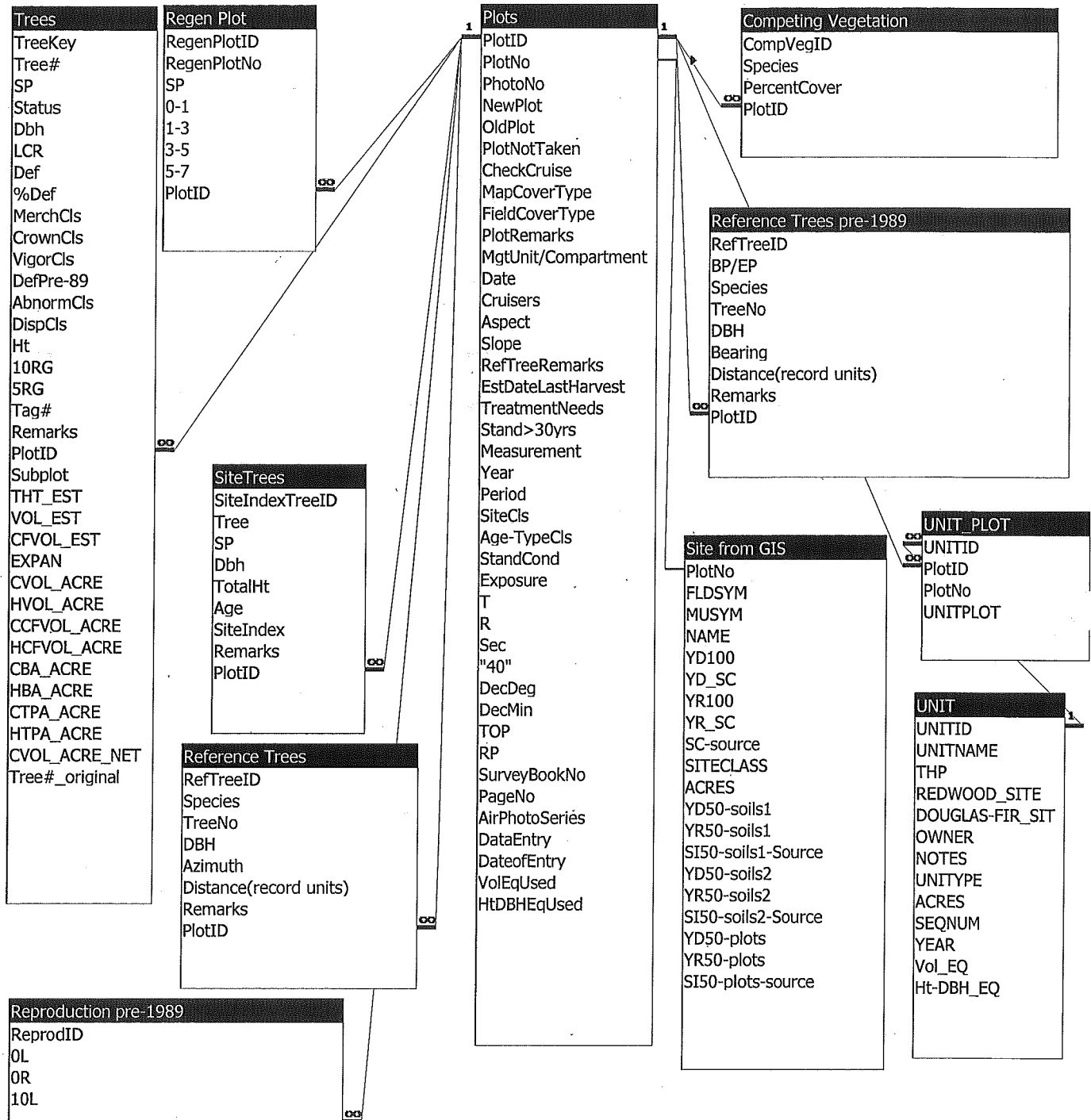
1. IN the database create a table containing Plot#, and site for those plots that have YD site trees.
2. Join this table with 2005 FRI plots.
3. Convert the plot point layer to an integer raster with the SI50 as the raster value (plots with no site will have a value of 0)
4. Create a mask grid (to be used in nibble function) with all values set to null except the plots that have a site tree using the equation -> tempyd = setnull(yd == 0, yd)
5. use the nibble function to assign all plots the site index of the closest plot with a site index -> ydSI = nibble(yd, tempyd)
6. used a visual basic code excerpt (see below) to find the underlying raster value of each plot to assign the appropriate site index.

CFI procedure (example shown using YD)

1. covert CFI point layer to a raster layer called CFI
2. using the raster "YD" shown in 3 above, combine YD raster with CFI raster using equation -> yd1 = con(isnull(cfi), con(yd == 0, cfi, yd), cfi)
3. create a mask for the nibble operation -> ydmask = con(isnull(C:\GIS\GIS\_Library\Forest\Jackson\temp\site\_index\yd), C:\GIS\GIS\_Library\Forest\Jackson\temp\site\_index\yd, setnull(C:\GIS\GIS\_Library\Forest\Jackson\temp\site\_index\yd == 0, yd))
4. use the nibble function to assign all CFI plots the site index of the closest FRI plot with a site index -> ydSI = nibble(yd, ydmask)

# Relationships for JSF\_CFI MASTER

Thursday, May 10, 2007





Note: Because of the Plot size change from 1984 to 1989 and the renumbering of trees in 1989, the growth routine has a large number of errors which cannot be resolved. This is a very long report, and is not included here. The report can be found on the JDSF network drive (fpjdsf01) at F:\Data\Inventory\CFI Database\error\_reports\archived\Growth\_errors\_1984to1989-explained.xls



# Growth Routine Error Report 1989 to 1999

err	comment	plot	P1ID	P1tree#	P2ID	P2tree#	remarks
Err6	P1 Status 2 and P2 doesn't exist. Mortality assumed	01-01	705	30	-999	-999	not found
Err8	P2 Status of 91 with no P1 tree. Zero Growth assumed	01-01	-999	-999	706	42	OK
Err8	P2 Status of 91 with no P1 tree. Zero Growth assumed	01-02	-999	-999	710	78	OK
Err8	P2 Status of 91 with no P1 tree. Zero Growth assumed	02-03	-999	-999	735	71	OK
Err8	P2 Status of 91 with no P1 tree. Zero Growth assumed	02-04	-999	-999	740	64	OK
Err8	P2 Status of 91 with no P1 tree. Zero Growth assumed	02-04	-999	-999	740	99	OK
Err8	P2 Status of 91 with no P1 tree. Zero Growth assumed	05-01	-999	-999	874	18	OK
Err6	P1 Status 1 and P2 doesn't exist. Mortality assumed	05-03	888	43	-999	-999	missing
Err8	P2 Status of 91 with no P1 tree. Zero Growth assumed	06-09	-999	-999	1006	36	OK
Err8	P2 Status of 91 with no P1 tree. Zero Growth assumed	06-09	-999	-999	1006	35	OK
Err8	P2 Status of 91 with no P1 tree. Zero Growth assumed	07-08	-999	-999	1071	87	OK
Err8	P2 Status of 91 with no P1 tree. Zero Growth assumed	08-04	-999	-999	1101	59	OK
Err8	P2 Status of 91 with no P1 tree. Zero Growth assumed	09-02	-999	-999	1137	71	OK
Err8	P2 Status of 91 with no P1 tree. Zero Growth assumed	09-02	-999	-999	1137	76	OK
Err6	P1 Status 1 and P2 doesn't exist. Mortality assumed	10-04	1202	169	-999	-999	not found
Err6	P1 Status 2 and P2 doesn't exist. Mortality assumed	10-04	1202	9	-999	-999	not found
Err8	P2 Status of 91 with no P1 tree. Zero Growth assumed	10-05	-999	-999	1215	79	OK
Err8	P2 Status of 91 with no P1 tree. Zero Growth assumed	11-02	-999	-999	1247	51	OK
Err8	P2 Status of 91 with no P1 tree. Zero Growth assumed	11-02	-999	-999	1247	52	OK
Err10	P1 Plotid 1251 does not exist in P2.	11-03					
Err8	P2 Status of 91 with no P1 tree. Zero Growth assumed	12-02	-999	-999	1308	3	OK
Err8	P2 Status of 91 with no P1 tree. Zero Growth assumed	12-03	-999	-999	1316	71	OK
Err8	P2 Status of 91 with no P1 tree. Zero Growth assumed	14-03	-999	-999	1376	70	OK
Err8	P2 Status of 91 with no P1 tree. Zero Growth assumed	16-03	-999	-999	1477	83	OK
Err8	P2 Status of 91 with no P1 tree. Zero Growth assumed	16-03	-999	-999	1477	87	OK
Err8	P2 Status of 91 with no P1 tree. Zero Growth assumed	16-03	-999	-999	1477	86	OK
Err8	P2 Status of 91 with no P1 tree. Zero Growth assumed	16-05	-999	-999	1487	44	OK
Err8	P2 Status of 91 with no P1 tree. Zero Growth assumed	16-05	-999	-999	1487	48	OK
Err9	P2 missed mortality (93) No P1 tree. Can't Process	16-05	-999	-999	1487	1151	OK
Err8	P2 Status of 91 with no P1 tree. Zero Growth assumed	16-07	-999	-999	1505	98	OK
Err8	P2 Status of 91 with no P1 tree. Zero Growth assumed	17-02	-999	-999	1522	103	OK
Err8	P2 Status of 91 with no P1 tree. Zero Growth assumed	17-03	-999	-999	1533	71	OK
Err8	P2 Status of 91 with no P1 tree. Zero Growth assumed	17-03	-999	-999	1533	72	OK
Err8	P2 Status of 91 with no P1 tree. Zero Growth assumed	18-03	-999	-999	1584	4	OK
Err8	P2 Status of 91 with no P1 tree. Zero Growth assumed	18-04	-999	-999	1592	41	OK
Err8	P2 Status of 91 with no P1 tree. Zero Growth assumed	18-04	-999	-999	1592	42	OK
Err8	P2 Status of 91 with no P1 tree. Zero Growth assumed	18-07	-999	-999	1613	85	OK
Err8	P2 Status of 91 with no P1 tree. Zero Growth assumed	19-06	-999	-999	1667	76	OK
Err8	P2 Status of 91 with no P1 tree. Zero Growth assumed	20-01	-999	-999	1673	18	OK
Err8	P2 Status of 91 with no P1 tree. Zero Growth assumed	21-01	-999	-999	1716	1	OK
Err8	P2 Status of 91 with no P1 tree. Zero Growth assumed	21-02	-999	-999	1724	90	OK
Err8	P2 Status of 91 with no P1 tree. Zero Growth assumed	22-01	-999	-999	1762	3	OK
Err8	P2 Status of 91 with no P1 tree. Zero Growth assumed	22-01	-999	-999	1762	4	OK
Err8	P2 Status of 91 with no P1 tree. Zero Growth assumed	22-01	-999	-999	1762	5	OK

Growth Routine Error Report 1999 to 2005

P1 Plot & tree#	year	P1SP	P1status	P1DBH	P1Ht	P1Tag#	P1Rmrks	P1Subplot	P2 Plot & Tree#	Year	SP	Status	Dbh	Ht	Tag#	Remarks	Subplot
07-04 45	1999	3	1	15.2			S	1	06-02 105	2005	3	2			105	no dbh or LCR	
07-07 44	1999	4	1	35		38			P2 Tree does not exist.	Not Found							
07-08 87	1999	3	91	11.8					P2 Tree does not exist.	Forked tree treated as 1 tree in 2005							
18-02 10	1999	9	1	20.3		96		0	P2 Tree does not exist.	Missed in 2005?							
06-05 58	1999	5	1	15.4	97				P2 Tree does not exist.	Missed in 2005?							
02-04 100	1999	3	2	15.1					P2 Tree does not exist	Not found							
									P2 Tree does not exist.	Not found in 2005							